

SAKSONOV, P.P.; ANTIFOV, V.V.; DOBROV, N.N.; SHASHKOV, V.S.; KOLEV, V.A.;  
PARSHIN, V.S.; LAVYDOV, E.I.; HAZGOVOROV, P.I.; MOFUCH, V.S.;  
NIKITIN, M.D.

Prospects for pharmacochemical protection against radiation  
injury in space flight. Probl. kosm. biol. 4:119-126 '65.  
(MIRA 18:9)

SP. 12.7, V.3.: MOROZOV, V.S.

Injuring effect of 660 and 120 Mev. protons and the effectiveness  
of pharmacological protection. Probl. kosm. biol. 4:401-410 '65.  
(MIRA 18:9)

RAZGOVOROV, B.L.; MOROZOV, V.S.; SHASHKOV, V.S.; ANTIPOV, V.V.; DOBROV,  
N.N.; KONNOVA, N.I.; L'VOVA, T.S.; SAKSONOV, P.P.

Effect of screening of separate parts of the animal body on  
the change in radiation reaction following action of gamma  
rays and high-energy protons. Probl. kosm. biol. 4:411-429 '65.  
(MIRA 18:9)

GAYDAMAKIN, N.A.; PEIRUKHIN, V.G.; SHASHKOV, V.S.; ANTIPOV, V.V.; SAKSONOV, P.P.

Morphological changes in the hemopoietic organs of mice  
following irradiation with high-energy protons. Probl. kosm.  
biol. 4:430-436 '65. (MIRA 18:9)

MOROZOV, V.S.; SHASHKOV, V.S.; DAVYDOV, B.I.; ANTIPOV, V.V.; SAKSONOV,  
P.P.; DOBROV, N.N.

Modeling radiation conditions during solar flares on the trajec-  
tory of the flight around the moon. Probl. kosm. biol. 4:701-  
708 '65. (MIRA 18:9)

L 14290-66 EWT(m)/EPF(n)-2/FCC/T IJP(c) GG/RD

ACC NR: AT6003874

SOURCE CODE: UR/2865/65/004/000/0401/0410

AUTHOR: Shashkov, V. S.; Morozov, V. S.

ORG: none

17, 44  
TITLE: Injurious effect of 660- and 120-mev protons and the efficacy of pharmacological and chemical protection

SOURCE: AN SSSR. Otdeleniye biologicheskikh nauk. Problemy kosmicheskoy biologii, v. 4, 1965, 401-410

TOPIC TAGS: proton, biologic radiation effect, radiation protection, mouse, RBE, cobalt, radioisotope, gamma irradiation, antiradiation drug

ABSTRACT: Efforts continue to partially estimate the biological effects of cosmic radiation by determining the RBE of high-energy protons. In this work male white mice weighing 18—21 g were subjected to Co<sup>60</sup> gamma-rays (dose power, 264 rad/min) and 120- and 660-Mev protons (dose power, 500—700 rad). The experiments were also designed to test chemical agents with a known radioprotective effect against x-rays and gamma-rays during proton irradiation. The animals were irradiated in plastic chambers

Card 1/3

L 14290-66

ACC NR: AT6003874

in groups of 10—5 controls and 5 protected mice. The  $LD_{50/30}$  for  $Co^{60}$  gamma-rays was calculated to be 600 rad, and for 660-Mev protons, 900 rad. Thus, the RBE of 660-Mev protons, according to the  $LD_{100}$  index, is 0.73. The comparative radioprotective effect of various substances was investigated in experiments, the results of which are shown in the following table.

Preparation	Co <sup>60</sup> gamma-irradiation in dose of 850 r ( $DL_{100/30}$ )		Irradiation with 660-Mev protons in dose of $1170 \pm 150$ rad ( $DL_{100}$ )		Irradiation with 120- Mev protons in doses of $1200 \pm 100$ rad ( $DL_{100}$ )	
	Number of mice	Number alive by 30th day	Number of mice	Number alive by 30th day	Number of mice	Number alive by 30th day
Cystamine	40	22	80	41	40	24
AET	40	30	60	49	40	30
Serotonin	40	24	30	15	40	22
5-methoxytryptamine	40	28	30	21	40	28
Tryptamine	20	8	20	5	—	—
5-hydroxytryptophan	20	8	20	4	—	—
Control	40	0	160	3	60	2
Biological control	20	20	60	59	20	20

Card 2/3

L 14290-66

ACC NR: AT6003874

Experimental results showed that the RBE of both 660- and 120-Mev. protons for mice, as compared with electromagnetic radiation, does not exceed 1. Furthermore, the known radioprotective substances retain their effectiveness during irradiation with high-energy protons. The authors express thanks to Corresponding Member of the Academy of Sciences, SSSR, D. I. Blokhintsev, Director OIYaI. Further thanks is extended to Professor V. P. Dzhelenov, Director of the Laboratory of Nuclear Problems OIYaI, for making possible the research work with protons. Orig. art. has: 4 tables. [ATD PRESS: 4091-F]

SUB CODE: 06 / SUBM DATE: none / ORIG REF: 019 / OTH REF: 021

CC  
Card 3/3



L 14291-66 EWT(m)/ETC(F)/EPF(n)-2/EWG(m) GG/RD

ACC NR: AT6003875

SOURCE CODE: UR/2865/65/004/000/0411/0429

AUTHOR: Razgovorov, B. I.; Morozov, V. S.; Shashkov, V. S.; Antipov, V. V.;  
Dobrov, N. N.; Konnova, N. I.; L'vova, T. S.; Saksonov, P. P.

ORG: none

TITLE: Effect of screening individual parts of the body of animals on changes in radiation reaction on exposure to gamma rays and high-energy protons

SOURCE: AN SSSR. Otdeleniye biologicheskikh nauk. Problemy kosmicheskoy biologii, v. 4, 1965, 411-429

TOPIC TAGS: radiation shielding, RBE, rat, animal physiology, gamma irradiation, cobalt, radioisotope, proton, irradiation, radiation biologic effect

ABSTRACT: Previous experiments showed that screening of individual organs or parts of the body during large doses of x-rays or gamma rays can change both the degree of radiation sickness and the number of deaths. In this work experiments were conducted to determine the effect of screening  
during irradiation of animals with gamma rays and 120-Mev protons.

White rats of both sexes were used.  $\text{Co}^{60}$  gamma irradiation with dose power of 15.5 r/min was used. Proton irradiation was conducted through Card 1/4

L 14291-66

ACC NR: AT6003875

8

lead-shielded polyethylene blocks to lower the dose (dose power  $60 \pm 10$  rad/min). During gamma irradiation, parts of the body were screened with steel plates (15 cm thick) of different widths. Plexiglas blocks 12—15 cm thick, which almost completely blocked the proton flux from the screened part, served as shields during proton irradiation. The biological effect of radiation under these conditions was determined by the survival rate of animals during a 30-day period after irradiation. Localized shielding during gamma irradiation of rats in a dose of 930 rad produced a definite increase in the survival rate, which was most effective during screening of the abdomen (80% survival rate as compared with 6% in the control). It was concluded that screening of the abdomen lowers the mortality index to the greatest degree and also is most effective in easing the course of radiation sickness and lessening the degree of leukopenia.

In a second series of experiments, the abdomens of rats were shielded with plexiglas blocks of different widths during irradiation with protons in the following dose ranges: 800—1050 rad and 1100—1300 rad, and with gamma rays in doses of 930, 1100, and 1400 rad. It was found that screening the abdomen with a block 6 cm wide during proton irradiation with

Card 2/4

L 14291-66

ACC NR: AT6003875

800—1050 rad increased the survival rate to 86.4% (as compared with 19.4% in the control). A high survival rate (96.7—100%) was also observed when the abdomen was screened with blocks of various widths during gamma irradiation (930 rad). Screening of the abdomen during proton irradiation also prevented the development of severe gastrointestinal disease in many cases and caused rats to lose less weight. Experimental animals recovered weight more quickly and even exceeded initial weight levels.

Weight changes during gamma irradiation followed the same pattern.

Preliminary experiments were also conducted to show the effect of screening under the combined influence of protons and acceleration or vibration. Results showed that neither 30 min of acceleration (10g) nor 1 hr of vibration (700 cps, amplitude 0.005 min) altered the effectiveness of screening during proton irradiation (doses 750—1100 rad and 1050—1300 rad, respectively). Furthermore, it was found that the effectiveness of screening the abdomen increases with increased radiation dose. There is not yet any adequate explanation of the screening effect although it may be connected with retention by the organism of undamaged tissue sections.

Card 3/4

L 14291-66

ACC NR: AT6003875

Orig. art. has: 5 figures and 4 tables. [ATD PRESS: 4091-F]

SUB CODE: 06 / SUBM DATE: none / ORIG REF: 011 / OTH REF: 010

*OC*  
Card 4/4

L 14292-66 EWT(m)/EPF(n)-2 GG/RD :

ACC NR: AT6003876

SOURCE CODE: UR/2865/65/004/000/0430/0436

AUTHOR: Gaydamakin, N. A.; Petrukhin, V. G.; Shashkov, V. S.; Antipov, V. V.; 5/  
Saksonov, P. P. B+/

ORG: none

TITLE: Morphological changes in the hematopoietic organs of mice after  
irradiation with high-energy protons 19, 44, 55.

SOURCE: AN SSSR. Otdeleniye biologicheskikh nauk. Problemy kosmicheskoy biologii,  
v. 4, 1965, 430-436

TOPIC TAGS: proton, hematopiesis, RBE, morphology, irradiation, mouse, gamma  
irradiation, cobalt, radioisotope, ionizing irradiation, radiation biologic effect.

ABSTRACT: Pathological changes in the morphology of the hematopoietic organs of  
male mice were studied after proton and gamma-irradiation. Some animals  
were subjected once to proton irradiation (dose, 830 rad; dose power, 400—  
600 rad/min), and others were irradiated from a Co<sup>60</sup> source (dose, 650 r;  
dose power, 273 r/min). Control animals were not irradiated. The mice  
were killed with ether 3, 7, 15, 30, and 60 days after irradiation, and  
cells of the spleen, thymus gland, and bone marrow of the femur were

Card 1/3

2

L 14292-66

ACC NR: AT6003876

examined microscopically. In animals that died from radiation sickness (9—12 days after irradiation), hemorrhages in the lungs and intestine were frequently observed. Comparison of the weight coefficients of the spleen and thymus (both showing a two-phase increase) did not reveal any statistically reliable differences in the effects of the two different types of irradiation on these organs. Observation of animals and comparative study of hematopoietic organs show that changes due to irradiation with protons and gamma-rays are similar. In the first few days after irradiation, the volume of follicles in the spleen decreased, and areas of myelopoiesis disappeared from the pulp. In the thymus gland, depletion of the cortical substance of lymphocytes was observed, and in the bone marrow destruction of the reticular stroma occurred. It must be noted that changes were less severe during irradiation with protons than with gamma-rays. However, complete recovery of the spleen did not occur in either case by the 60th day after irradiation. In general, it was concluded that restorative processes in all three structures studied proceeded more slowly in the gamma-irradiated animals. Previous experiments have also shown that there are no noticeable differences in the morphological

Card 2/3

L 14292-66

ACC NR: AT6003876

reactions of animals to different types of ionizing radiation. The degree of affliction, however, depends on the physical nature of the form of radiation, and doses vary. Orig. art. has: 1 table. [ATD PRESS: 4091-F]

SUB CODE: 06 / SUBM DATE: none / ORIG REF: 013 / OTH REF: 004

PC  
Card 3/3

L 14252-66 FSS-2/EWT(1)/FS(s)/EWP(n)/FS(v)-3/EEC(k)-2/FCC/EWA(h) SCTB TT/DD/RD/GW

ACC NR: AT6003911

SOURCE CODE: UR/2865/65/004/000/0701/0708

AUTHOR: Morosov, V. S.; Shashkov, V. S.; Davydov, B. I.; Antipov, V. V.;  
Saksonov, P. P.; Debrov, N. N.

84  
82

ORG: none

<sup>2</sup>  
TITLE: Modeling of radiation conditions on a circumlunar trajectory during a solar flare

SOURCE: AN SSSR. Otdeleniye biologicheskikh nauk. Problemy kosmicheskoy biologii, v. 4, 1965, 701-708

TOPIC TAGS: space flight simulation, mouse, radiation protection, lunar flight, radiation biologic effect, biologic acceleration effect, solar flare, gamma irradiation, lunar trajectory, radiation belt, antiradiation drug

ABSTRACT: The possibility of modeling the biological effect of radiation on a lunar flight which includes a short solar flare was demonstrated. White mice fed a special food concentration and kept in a biological unit were subjected to gamma-irradiation. Acute irradiation of other animals was conducted in plexiglas cages. In all cases the radiation dose was

Card 1/3



L 14252-66

ACC NR: AT6003911

2

900--920 r. Dose power during acute irradiation was 18 r/min and during "solar flare" a maximum of 2.5 r/min (duration of flare, 24 hr). On the simulated lunar trajectory, the animals received a dose of 60--80 r while passing through the "radiation belts." Before the solar flare, the mice were injected with the following radioprotective agents: cystamine dihydrochloride, AET, and 5-methoxytryptamine hydrochloride. 44

The experimental results showed that the effects of this pharmacological protection were slight as compared with unprotected animals. AET was the most effective radioprotective agent during both "lunar flight" and acute irradiation. On the lunar flight the animals were subjected to an acceleration of 20 g for 5 min before irradiation and at the end of the flight. It is suggested that the observed lowering of the biological effect of radiation during lunar flight (only 33% of the mice died, as against 90% after acute irradiation) is due not only to the lowered dose power, but also to acceleration. It is known that acceleration can alter the reactivity of an animal to subsequent irradiation. Previous experiments also suggest that preliminary irradiation of 60 r (in the radiation

Card 2/3

L 14252-66

ACC NR: AT6003911

belts) reduced the effectiveness of the subsequent high dose during solar flare.  
It was concluded that modeling of radiation conditions for any spaceflight  
trajectory should be possible. Orig. art. has: 2 figures and 3 tables.  
[ATD PRESS: 4091-F]

SUB CODE: 06 / SUBM DATE: none / ORIG REF: 006 / OTH REF: 006

FLW  
Card 3/3

I. 18003-66 EWT(1)/EWT(m)/ECC/EWA(h) SCTB DD/GW  
~~ACC NR:~~ AP6007752 SOURCE CODE: UR/0293/66/004/001/0172/0174

AUTHOR: Morozov, V. S.; Shashkov, V. S.; Davydov, B. I. 43  
 P

ORG: none

TITLE: Modeling the biological effect of a depth dose from a monoenergetic proton flux 19

SOURCE: Kosmicheskiye issledovaniya, v. 4, no. 1, 1966, 172-174

TOPIC TAGS: corpuscular radiation, radiation effect, RBE, high energy proton

ABSTRACT: Previous experiments suggested that physical protection (shielding) sometimes aggravates the effect of corpuscular radiation on living organisms. Unlike electromagnetic radiation, heavy particles create a higher ionization density along their path and at the end of their penetration (i.e., linear energy losses increase with decrease in particle velocity, and RBE likewise increases). Thus, corpuscular radiation can have a widely varying biological effect on different parts of an organism. Experiments were conducted to trace the change in biological effectiveness of particles during their passage through tissue until they were stopped. Mice were placed in rows perpendicular to the axis of a monochromatic beam of 120-Mev protons. Animals were irradiated with a dose of 1600 rad (dose power, 50 rad/min from a synchrocyclotron). One group of animals received an intraperitoneal injection of the

Card 1/2

UDC: 629.198.621

L 18003-66

ACC NR: AP6007752

antiradiation agent AET (dose, 150 mg/kg) 15--20 min before irradiation. The survival

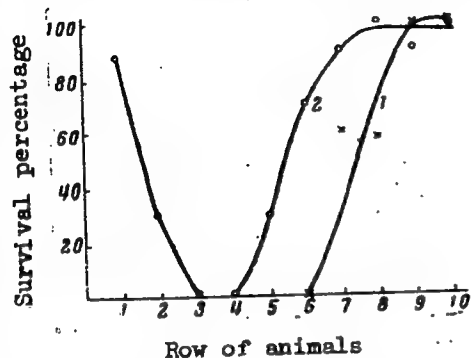


Fig. 1. Survival percentage of irradiated animals depending on the row occupied

1 - Control; 2 - AET.

percentage and average length of life of animals dying within 30 days were determined (see Fig. 1). It should be noted that AET had no protective effect in the 3rd--4th row. Orig. art. has: 3 figures and 1 table. [JS]

SUB CODE: 06/ SUBM DATE: 23Oct65/ ORIG REF: 003/ OTH REF: 003/ ATD PRESS: 4213

Card 2/2 mg5

TO: MR. J. Edgar Hoover, D.A.; FROM: MR. J. Edgar Hoover, D.A. SAKSO  
SUBJECT: YIP KAI-SHEK, Y.K.S.

Re: Mr. J. Edgar Hoover, D.A. SAKSO  
prosecutive activity. Date: 1 1 60. 19 no. 433-101 N-2 1-1.  
(10 1 19:1)

L 23976-bb ENT(1)/ENT(m)/FCC/EWA(h) SCTB DD/RD/GW

ACC NR: AT6003847

SOURCE CODE: UR/2865/65/004/000/0119/0126

AUTHOR: Saksonov, P. P.; Antipov, V. V.; Dobrov, N. N.; Shashkov, V. S.;  
Kozlov, V. A.; Parshin, V. S.; Davydov, B. I.; Razgovorov, B. L.;  
Morozov, V. S.; Nikitin, M. D.

ORG: none

68

B+1

TITLE: Perspectives of pharmacochemical <sup>2/</sup>protection from radioactive damage during cosmic flights

SOURCE: AN SSSR. Otdeleniye biologicheskikh nauk. Problemy kosmicheskoy biologii, v. 4, 1965, 119-126

TOPIC TAGS: astronaut, space medicine, radiation biologic effect, antiradiation drug, biologic acceleration effect, mouse, experiment animal, space physiology, closed ecology system, space flight

ABSTRACT: The authors consider cosmic radiation's real danger for astronauts, particularly during long flights. The work is a survey on existing radioprotectors and a general discussion of biologic conditions in cosmic flight, future research, and requirements for radioprotectors. The present chemical compounds, Mercamine HCL, its salicylate and disulfide, and AET appear sufficiently effective for clinical use against

Card 1/2

2

L 23976-66

ACC NR: AT6003847

X or gamma rays. Laboratory tests on mice showed that some compounds of the aminothiols series (cystamine, cysteamine, serotonin, AET) exerted significant protective effect in proton irradiation of 600 and 120 Mev. In the search for radioprotectors, other factors affecting the astronaut must also be taken into account, such as weightlessness, vibration, acceleration and changes in pressure. Tests on laboratory animals subjected to such conditions prior to irradiation showed no effect on radiation sickness, but vibration after irradiation was apt to prolong the sickness. Some of the radioprotectors tested in mice and dogs had an adverse effect on stability of the organism under vibration and acceleration. The authors call for studies to establish a stable ecologic system in the cabin which can accompany the astronaut on long trips, for models simulating cosmic flight conditions particularly in regard to radiation dose, and for radioprotective compounds to be compatible with all these conditions. Orig. art. has: none.

SUB CODE: 06, 22/ SUBM DATE: none/ ORIG REF: 040/ OTH REF: 028

Card 2/2 W

ACC NR: AT6036632

SOURCE CODE: UR/0000/66/000/000/0335/0336

AUTHOR: Saksonov, P. P.; Antipov, V. V.; Dobrov, N. N.; Kozlov, V. A.; Shashkov, V. S.

ORG: none

TITLE: Problems of pharmacochemical protection of the organism against ionizing radiation on spaceflights [Paper presented at the Conference on Problems of Space Medicine held in Moscow from 24-27 May 1966]

SOURCE: Konferentsiya po problemam kosmicheskoy meditsiny, 1966. Problemy kosmicheskoy meditsiny. (Problems of space medicine); materialy konferentsii, Moscow, 1966, 335-336

TOPIC TAGS: radiation protection, pharmacology, ionizing radiation biologic effect, cosmic radiation biologic effect, life support system, radiation tolerance, space medicine

ABSTRACT:

Although some pharmacochemical substances have a demonstrated ability to increase the radioresistance of both humans and animals, they cannot be used unconditionally in spaceflight. Special features of the cosmic radiation effect which must be considered in the search for effective

Card 1/3



ACC NR: AT6036632

work capacity even briefly, and also must be available in convenient medicinal form. In addition, radioprotectors used in spaceflight must not damage the hereditary structures or disrupt the physiological functions of links in the spacecraft life-support system.

[W.A. No. 22; ATD Report 66-116]

SUB CODE: 06 / SUBM DATE: 00May66

Card 3/3

I 28444-66 EWT(1) SCTB DD

ACC NR: AP6015411

SOURCE CODE: UR/0216/66/000/003/0346/0354

AUTHOR: Gaydamakin, N. A.; Petrukhin, V. G.; Antipov, V. V.; Saksonov, P. P.; Shashkov, V. S.

27

ORG: none

TITLE: Pathomorphological changes in hematopoietic organs of mice during the combined action of certain types of ionizing radiation and dynamic spaceflight factors

SOURCE: AN SSSR. <sup>2</sup> Izvestiya. Seriya biologicheskaya, no. 3, 1966, 346-354

TOPIC TAGS: mouse, biologic acceleration effect, biologic vibration effect, radiation biologic effect, hematopoiesis, bone marrow, radiation injury, synergy

ABSTRACT: The synergistic effect of ionizing radiation and vibration or transverse acceleration on the spleen and bone marrow was investigated in 9 series of experiments on 245 male mice. In the 1st and 2nd series experimental animals were exposed to a 1-hr vibration (70 cps) period 1 or 3 days before proton irradiation with a 830 to 875 rad dose. In the 3rd and 4th series experimental animals were exposed to the same vibration period 3 or 5 days following irradiation. In the 5th series

Card 1/2

I 28444-66

ACC NR: AP6015411

experimental animals were exposed to the action of transverse acceleration applied 10 times over a 30 min period 23 hr before gamma irradiation with a 700 r dose, and in the 6th series the transverse acceleration action was applied 24 hr following irradiation. The 7th, 8th and 9th series served as controls. Animals were observed over a 60-day period to determine pathomorphological changes of the spleen and bone marrow by microscopic investigation. Study data show that the combined action of ionizing radiation and vibration or transverse acceleration markedly changes the degree and nature of pathomorphological shifts in hematopoietic organs. Exposure to vibration 3 days and particularly 1 day prior, to irradiation intensified the depletion of spleen and bone marrow and accelerated the restoration of all the hematopoietic processes. The effect of vibration applied 3 days and particularly 5 days after irradiation markedly increased destructive changes; during the recovery period necrotic foci appeared in the bone marrow and spleen, and reparative processes were prolonged. Transverse acceleration applied 24 hr prior to gamma irradiation reduced depletion of the hematopoietic organs and accelerated their reparation. Transverse acceleration applied 24 hr after irradiation did not affect radiation injuries of the hematopoietic organs. Orig. art. has: 6 figures. [06]

SUB CODE: 06/ SUBM DATE: none/ ORIG REF: 020/ ATD PRESS: 5005

Card 2/2 IC

L 34975-66 EWT(1) SCFB DD/RB  
 ACC NR: AP6019602 SOURCE CODE: UR/0293/66/004/003/0482/0491  
 AUTHOR: Davydov, B. I.; Antipov, V. V.; Kozlov, V. A.; Saksonov, P. P.;  
 Shashkov, V. S. 50  
 49  
 10  
 ORG: none  
 TITLE: The problem of using radioprotective pharmacological agents under spaceflight conditions 2  
 SOURCE: Kosmicheskiye issledovaniye, v. 4, no. 3, 1966, 482-491  
 TOPIC TAGS: manned spaceflight, radiation protection, cystamine,  
 methoxytryptamine, acceleration, animal physiology  
 ABSTRACT: In tests on mice (exposed three times to 44.4 G, 1.4 G/sec accelerations, with 5 min per exposure and 5 min between exposures on a centrifuge with a 4.25 m arm length) and guinea pigs (exposed twice to 22.0 G, 0.7 G/sec with 5 min between exposures), lowered resistance to acceleration was noted after injections of cystamine (80—150 mg/kg), AET (15—150 mg/kg), 5-methoxytryptamine (75 mg/kg), serotonin (50 mg/kg), and aminazine (1—10 mg/kg). A change in resistance after injections of phenazine (2—10 mg/kg) and strychnine (0.05 mg/kg) was insignificant. Thirty min after the combined injection of phenazine (5—10 mg), strychnine (0.5—1.0 mg), and aminazine (2.5 mg), the EKG's and respiration of dogs exposed to 6—8 G (0.2—0.3 G/sec) did not differ from those of control centrifuged animals.  
 Card 1/2 UDC: 615.7.035.1:614.876(202)

L 34975-66

ACC NR: AP6019602

It was concluded that extreme caution should be exercised in recommending radio-protectors, especially AET, cystamine, and 5-methoxytryptamine, for use on space-flights. The authors thank S. N. Komarov for his active participation in the study. [CD]  
Orig. art. has: 5 figures and 3 tables.

SUB CODE: 06,22/ SUBM DATE: 28Feb66/ ORIG REF: 017/ OTH REF: 013/ ATD PRESS: 5029

Card 2/2 JS

**APPROVED FOR RELEASE: 08/09/2001**

**CIA-RDP86-00513R001548710003-2"**

SHASHKOV, V.S.; FEDOSEYEV, V.M.; BURKOVSKAYA, T.Ye.; SAKSONOV, P.P.; ANTIPOV, V.V.;  
YEVDOKIMOV, Yu.N.

Study of the radioprotective activity of some newly synthesized  
thiazoline derivatives. Radiobiologia 4 no.6:927 '64. (MIRA 18:7)

1. Moskovskiy gosudarstvennyy universitet im. M.V.Lomonosova,  
khimicheskoy fakul'tet.

1. SHASHKOV, YE. P.

2. SSSR (600)

4. Furnaces

7. Lining pyrite furnaces of the "G" type.  
Bum. prom. 27 No. 9, 1952

9. Monthly List of Russian Accessions, Library of Congress, February 1953, Unclassified.



USSR/Metallurgy - Pyrometry, Optical Methods Mar 52

"Effect of the Surface Roughness and Film of Solid and Liquid Metals on the Precision of Temperature Measurement by Optical Methods," B. V. Stark, Corr Mem Acad Sci USSR; Yu. M. Shashkov

"Iz Ak Nauk SSSR, Otdel Tekh Nauk" No 3, pp 395-404

Develops formula for determining film transparency, i.e., thickness of oxide film within which emission of metal covered with film depends on the film thickness. Establishes that neither monochromatic nor polychromatic pyrometers provide for precise

244T77

temp measurement of metals, covered with films having smooth separation surfaces, in zone of transparency. No precision can be achieved also in case of metals with rough surface and metals covered with films having rough separation surfaces, but in this case monochromatic pyrometer provides for higher precision.

244T77

START, ACAD. B. V. SHASHKOV, YU. M.

Fusion

Refractometric method of investigating fusions. Dokl. AN SSSR 85 no. 1, 1952.

Monthly List of Russian Accessions, Library of Congress, November 1952. UNCLASSIFIED.

... .. VI. A. SHASHOV

... .. I. I.  
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... .. the fact that the same  
... .. as well as for solids, liquids,  
... ..  
... .. for the study of cells.

156T8

SHASHKOV, YU.M.

Chem ✓ Refraction of inorganic compounds. Yu. M. Shashkov and T. P. Kolesnikova. *Zhur. Neorg. Khim.* 1, 2232 (1956).—The refraction  $R$  was calcd. for 130 compds. (50 of which are presented in tabular form). From an analysis of these data it appeared that the fact established earlier (Batsanov, *C.A.* 49, 8852b), that the value of  $R$  for the  $H_2O$  of crystn. is const. in various compds. is a specific case of a

more general phenomenon, i.e. that various components retain their values of  $R$  in compds. even for cases in which their individuality is not retained.

I. Roytar Leach

2

any

SHASHKOV, YU. M.

137-58-5-9457

Translation from: Referativnyy zhurnal, Metallurgiya, 1958, Nr 5, p 92 (USSR)

AUTHORS: Petrov, D.A., Kekua, M.G., Khvostikova, V.D., Shashkov, Yu.M., Suchkova, A.D.

TITLE Producing Single Crystals of Silicon (O poluchenii mono-kristallov kremniya)

PERIODICAL: V sb.: Vopr. metallurgii i fiz. poluprovodnikov. Moscow, AN SSSR, 1957, pp 41-46

ABSTRACT: The production of single crystals of Si by drawing from a melt and vertical floating-zone refining is described. Drawing was performed in an apparatus consisting of 3 parts: a vacuum circulation chamber connected with an evacuation system and equipped with electrical leads and mechanism for raising and rotating the crucible; a working chamber consisting of a metal water-cooled cylinder with viewing window; and heads with a mechanism for raising and rotating the seed crystal. The fusion of the Si in a quartz crucible mounted on a graphite base was done by a slit heater made of spectrally pure graphite, with graphite screens around it. Smelting was in vacuum ( $10^{-4}$ - $10^{-5}$  mm Hg). Si produced by the Beketov method was employed in

Card 1/2

137-58-5-9457

### Producing Single Crystals of Silicon

the drawing. After the Si was fused, a thermal regime that assured crystallization of the melt from its center was chosen. The seed was immersed in the melt, and drawing began after it was fused. Single crystals were obtained after the material had been drawn 1, 2, or 3 times. It is noted that the presence of a film on the melt and poor contact between the seed crystal and the melt may cause the crystal drawn to be a polycrystalline. Vertical floating-zone refining was performed in an apparatus consisting of a vacuum chamber in which a Si bar, produced by drawing, was mounted vertically. A Ta heater, creating a zone of fusion within the specimen, moved along the specimen at a rate of  $\sim 2$  mm/min. It was found that a given degree of superheating of the zone was a condition for the production of a single crystal by this method. In a polycrystalline specimen a monocrystalline portion was produced only after several passes, while this was accomplished on the first pass when a monocrystalline seed crystal was employed. Single crystals of Si with resistivities of 15-60 ohm/cm were produced on these apparatus.

fu. Sh.

1 Single crystals--Growth    2. Single crystals--Resistivity    3. Applications

Card 2/2

137-58-4-6982

Translation from: Referativnyy zhurnal, Metallurgiya 1958 Nr 4 p 96 (USSR)

AUTHORS: Petrov, D. A. Shashkov, Yu. M., Akimchenko, I. P.

TITLE: Diffusion of Antimony and Germanium in Silicon (Diffuziya sur'my i germaniya v kremnii)

PERIODICAL: V sb.: Vopr. metallurgii i fiz. poluprovodnikov. Moscow AN SSSR, 1957. pp 130-132

ABSTRACT: The radioactive isotopes  $\text{Sb}^{124}$  and  $\text{Ge}^{71}$  were used to determine the coefficient of diffusion  $D$  of Sb and Ge in Si. Diffusion was performed in large crystalline specimens having resistivities of tenths of an ohm/cm. These were of the p-type, cut transversely from bars obtained by extraction from the melt by the Chokhralskiy method. A thin layer of  $\text{Sb}^{124}$  and  $\text{Ge}^{71}$  was sprayed on the specimens in vacuum. Annealing was performed in quartz ampoules filled with Ar, these in turn being housed in evacuated ampoules. The temperature of annealing was maintained to within  $\pm 5^\circ$ . Distribution of the concentrations of the diffused elements through the specimen was determined by the radioactivity of the abraded layer and the radioactivity of the specimen. It was found that the  $D_{\text{Sb}}$  at  $940-1300^\circ$  could be described by the equation:

Card 1/2

137-58-4-6982

Diffusion of Antimony and Germanium in Silicon

$0.112 \exp(-66,000/RT) \text{ cm}^2/\text{sec}$  and the  $D_{\text{Ge}}$  at 1150-1350° by the equation:  
 $6.26 \cdot 10^5 \exp(-121,820/RT) \text{ cm}^2/\text{sec}.$

1. Antimony--Germanium--Diffusion    2. Silicon--Applications

Yu. Sh.

Card 2/2



AUTHORS: Petrov, D.A. and Shashkov, Yu. M. (Moscow). 24-5-12/25

TITLE: Device for growing crystals of high activity metals directly from powder without a crucible. (Ustanovka dlya bestigel'nogo vyrashchivaniya kristallov vysokoaktivnykh metallov neposredstvenno iz poroshka).

PERIODICAL: "Izvestiya Akademii Nauk, Otdeleniye Tekhnicheskikh Nauk" (Bulletin of the Ac.Sc., Technical Sciences Section), 1957, No.5, pp.102-103 (U.S.S.R.)

ABSTRACT: This paper was presented at the First All Union Conference on apparatus for semi-conductor metallurgy held at the Institute of Metallurgy, Ac.Sc. U.S.S.R. (Institut Metallurgii AN SSSR). The design is based on the principle proposed by Verneuil, M.A. in 1904 (1) for growing precious stones by feeding material from the top onto a molten end of a seeding, lowering the seeding away from the heating zone at a speed corresponding to the speed of feeding-in new material. A sketch of the device is given in Fig.1. The melting of the top end of the specimen is effected directly by means of a 5 Mc 15 kW oscillator. Such high frequency heating excludes any possibility of contamination by the heating substance as takes place, for instance, in an analogous device described by P. H. Keck et alii (2). A photo of the device is shown in Fig.2, whilst Fig.3 shows a photo of a specimen

Card 1/2

SHASHKOV, Yu.M.

Nekotorye voprosy zonnay plavki.

report submitted for the 5th Physical Chemical Conference on  
Steel Production.

MOSCOW - 30 JUN 69

SHASEFOV, Yu.M.

Elektroprovodnosty titanosodenzhashchikh shlakov.

report submitted for the 5th Physical Chemical Conference on  
Steel Production.

SHASEFOV 30 JUN 1979

24(6)

PHASE I BOOK EXPLOITATION

SOV/2117

Sovetskoye po eksperimental'noy tekhnike i metodam vysokotemperaturnykh isledovaniy, 1950

Experiments in high temperature technology and methods of investigation at high temperatures. Transactions of the Conference on Experimental Techniques and Methods of Investigation at High Temperatures. Moscow, AN SSSR, 1950. 128 p. (Series: Khimicheskaya osnovy proizvodstva metall) 2,200 copies printed.

Naup, Ed.: A.M. Samarin, Corresponding Member, USSR Academy of Sciences; Ed. of Publishing House: A.L. Bunkovskiy.

PURPOSE: This book is intended for metallurgists and metallurgical engineers.

COVERAGE: This collection of scientific papers is divided into six parts: 1) thermodynamic activity and kinetics of high-temperature processes; 2) constitutive diagrams and kinetics of high-temperature of liquid metals and slags; 3) physical properties of liquid metals and slags; 4) physical properties of solid metals; 5) pyrometry; and 6) general questions. For more specific coverage, see Table of Contents.

Shanov, Yu.M. Method of Measuring Electrical Conductivity of Molten Slags 306

Miklin, Yu.P., and O.A. Yarin. Measurement of Surface Charge Density of Liquid Metal in Contact With Slag 313

Nekhendzi, Yu.A., and A.M. Samarin. U-Shaped Test Specimen for Determining Fluidity of Alloys 318

Ditchevich, M.O., and Yu.A. Nekhendzi. Solidification and Related Phenomena as Functions of Physicochemical Constants of Alloys 351

Bidulya, P.N., and N.A. Trubitsyn. Measurement of Linear Shrinkage and Resistance to Hot-Crack Propagation in Steel 367

A versatile new instrument was developed for determining free linear shrinkage, hindered (or retarded) shrinkage, forces developing during hindered shrinkage, and resistance of the metal to the formation of hot cracks. By means of this instrument it was shown that steel with a peritectic composition (about 0.2 percent C) exhibits maximum resistance to the formation of hot cracks. This resistance falls sharply both with an increase and an increase in carbon content. But with an increase the resistance falls only until a content of 0.5 percent C has been reached; with greater amounts of carbon the resistance begins to rise again. The effect of hydrogen content and cooling temperature on hot-crack formation were also investigated.

Premov, A.P. Investigation of the Properties of Steel in the Liquid State and at the Temperature of Crystallization 389

Znachikov, S.G., and V.V. Mikheylov. Methods of Determining the Heat of Formation of Slag and the Heat of Evaporation of Combined Water in Iron Ores 397

Card 14/38

PLATE 1 BOOK EXPIRATION

207/566

Sovetskoye gosudarstvennoye izdatel'stvo, Moscow, 1957  
Voprosy metallurgii i fiziki poluprovodnikov: Izv. 3-ego sovetskoyanizatsionnogo (problems in the metallurgy and physics of semiconductors) Transactions of the Third Conference, Moscow, Izdatel'stvo AN SSSR, 1959. 129 p. English slip inserted. 3,200 copies printed.

Sponsoring Agency: Akademiya nauk SSSR. Institut metallurgii i fiziki  
A. A. Rykova. Resp. Ed.: R. B. Abrikosov, Doctor of Chemical Sciences;  
Ed. of Publishing House: P. F. Zolotov.

WFOPS: This collection is intended for technical and scientific personnel concerned with the investigation and production of semiconductor materials. It may also be used by students in schools of metallurgy.

CONTENTS: The collection contains reports submitted at the Third Conference on Semiconductor Materials, held at the Institute of Metallurgy, Izv. 3-ego Sovetskoyanizatsionnogo, Moscow, in May 1957. The reports deal with problems of obtaining and investigating germanium, silicon, and semiconductor compounds. The collection was first edited by D. A. Petrov, Doctor of Technical Sciences. References accompany most of the reports.

Galimov, V. V. On the Problem of the Role of Some Factors in the Growth Process of Single Crystals from a Melt. 23

Polyakov, I. B. Investigation of Noise Zones of Diamond-Type Crystals Grown from the Melt. 29  
Sikavits, Academician (Academy of Sciences, Hungarian People's Republic). Concerning the Problem of Semiconductor Polymers. 40

Majewski, Z. (Institute of Basic Technical Problems, Polish Academy of Sciences). Properties of P-N Junctions in Germanium Single Crystals Withdrawn from the Melt by Pulling. 43

Somovskiy, I. (Institute of Physics, Polish Academy of Sciences). Effect of the Introduction of Minority Current Carriers on Light Reflection from Germanium. 49

Pure, A. A., V. Ya. Rozent, and Ya. G. Maslennik. Diffusion and Solubility of Iron and Silver in Germanium. 52

Vysotskiy, A. B., and V. A. Ponomarev. Investigation of Moistening of Semiconductors with Salt. 57

Vasilevskiy, V. S., and Ya. G. Maslennik. Investigation of Segregation and Solubility of Some Impurities in Germanium During Crystallization from the Melt. (Institute of Technical Physics, Czechoslovak Academy of Sciences). Problems of Obtaining Pure Silicon. 68

Petrov, D. A., Ya. M. Shapovalov, V. V. Rozent, and V. D. Kiselevskiy. Raising of Silicon Single Crystals. 69

Belov, V. V. (Institute of Applied Physics, Chinese People's Republic). Importance of Using Pure Water for Washing Materials Used in Semiconductor Engineering. 78

Abrikosov, R. B., M. I. Aliev, A. A. Bakhvalov, and G. M. Aliev. Effect of Surface Impurities on the Physical Properties of Germanium. (Institute of Technical Physics, Czechoslovak Academy of Sciences). On the Diffusion of Certain Metals in Polycrystalline Germanium. 89

Dukhin, L. D., and M. M. Abrikosov. Problems of Alloying Semiconductors with Alloys. 94

Kiselevskiy, I. B., M. I. Viskovskiy, and Z. D. Ponomarev. Effect of Growth Conditions of Single Crystals of Cad and Cd on their Physical Properties. 107

Prokhorov, A. P., and G. A. Fedotkin. Effect of Temperature and Certain Impurities on the Dark Resistance and Photoconductivity of Cad Single Crystals. 112

Kiselevskiy, I. (Institute of Technical Physics, Czechoslovak Academy of Sciences). Semiconductor Compounds with an Excess of One of the Components. 117

Shchegolev, I. P. Effect of Surface Conditions on the Electrical Properties of Type A and B Compounds. 120

Petrov, D. A., A. A. Petrov, V. M. Voprosnik, A. G. Gilevskiy, and Ya. V. Kiselevskiy. Production and Investigation of New Semiconducting Materials. 127

AVAILABLE: Library of Congress

Card 5/5

JP/AC/08  
3/20/61

SOV/136-59-3-12/21

AUTHORS: Shashkov, Yu.M. and Savitskiy, I.V.

TITLE: Horizontal Zone-melting of Silicon (Gorizontal'naya zonnaya plavka kremniya)

PERIODICAL: Tsvetnyye Metally, 1959, Nr 3, pp 49 - 53 (USSR)

ABSTRACT: It is possible to obtain silicon with a high specific resistance by horizontal zone-melting if the purity of the quartz boat is high and there is no boron in the initial silicon. Ordinary apparatus cannot be used as cracking of the silicon specimen occurs whilst passing a zone along it and during cooling due to the difference in the coefficients of expansion for silicon and quartz. The present work describes apparatus which enables multiple zone-melting of silicon in a boat without cracking and the construction of a boat which allows the silicon to cool without cracking. All parts of the boat and the silicon specimen are maintained at a temperature higher than 800-900 °C similar to the method used by Taft and Horn (Ref 1). The whole apparatus is evacuated to  $10^{-4}$  mm Hg. It is shown in Figure 1, the main parts being: 1) the basic heater; 2) the additional heaters

Card1/3

Horizontal Zone-melting of Silicon

SOV/136-59-3-12/21

and, 3) the boat with the silicon. The basic heater is made of tantalum plate and is horse-shoe shaped (bottom right-hand corner of Figure 1). The speed of traverse of the boat can be varied from several hundredths to six mm per minute. There is a transfer of material to the last zone; therefore, the boat is sloped 5-7° to the horizontal. Cooling is carried out in one of the additional heaters but even so cracking of the specimen could still occur. This can be overcome by weakening the boat. Taft did this by decreasing the wall thickness but the present authors produced the same effect by making sectional boats which enables free movement of the silicon specimen. The absence of wetting of quartz by silicon and its high surface tension prevent the silicon from running between the individual sections. Results showed that no transverse cracks occurred in the specimen using this principle. Longitudinal cracks were avoided by cutting all the sections into two parts. In this way a whole specimen without any cracks can be obtained. The sectional boat principle could be applied to other cases. In the present case the

Card2/3

Horizontal Zone-melting of Silicon

SOV/136-59-3-12/21

resistance of silicon increases. The change in electrical resistance along the length of the specimen after five passes is shown in Figure 3. Curve 1 is after zone-melting and Curve 2 after an additional heat treatment at 600 °C for 2 hours. The first zone has much higher resistance than the last. There are 3 figures and 1 English reference.

Card 3/3



24.7100  
24.7500  
24 (7)  
AUTHORS: Shashkov, Yu. M., Akimchenko, I. P. 66168  
SOV/20-128-5-20/67  
TITLE: Diffusion of Lithium Into Silicon  
PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 128, Nr 5, pp 937-939 (USSR)  
ABSTRACT: The preparation of monocrystalline silicon alloyed with lithium became interesting. Owing to the chemical aggressiveness of lithium the diffusion of lithium into monocrystalline silicon presents the most suitable method of producing the alloy. This is also favored by the large value of the coefficient of the diffusion of lithium into silicon. The distribution of the admixture in the sample can be calculated with sufficient accuracy provided the diffusion coefficient of the admixture in the sample is known. Reference is made to a number of pertinent preliminary papers. It was of interest to examine existent data on the diffusion coefficient of lithium into silicon as a function of the perfection of the silicon crystals. This problem is also of theoretical interest. The dependence of the coefficient of the diffusion of lithium into silicon on the number of structural deficiencies in the crystal may be regarded as a criterion proving diffusion to proceed along the interspaces between the lattice nodes as

Card 1/4

66168

NOV/20-128-5-20/67

Diffusion of Lithium Into Silicon

well as verifying the mechanism of the dependence of the diffusion coefficient on the degree of structural perfection. In doing so, the existence of atoms between the lattice nodes and of substituting atoms is assumed. Substitution took place out of a thin sheet of metallic lithium applied to the surface of the sample after this had been cut and etched with an aqueous KOH solution. The upper side of the lithium sheet was then covered by a second sample. The execution of the experiments is briefly described. 2 Types of samples were used for these experiments, differing widely in the number of grooves formed in the etching process. They are purely monocrystalline and contain a great number of twins and dislocations. In the latter case diffusion took place perpendicular and parallel to the extension of the twins and dislocations. The samples were cut out of cast pieces, which had been prepared by a special method. A table listing the following data is included: characteristic properties of the samples, their resistance, the temperatures of diffusion-annealing, and the values obtained for the diffusion coefficient. These values are illustrated by a diagram on the coordinates

Card 2/4

66168

SOV/20-128-5-20/67

# Diffusion of Lithium Into Silicon

$\log D - 1/T$ . The experimental points on this curve form a straight line, which for the temperature interval 400 to 800° may be defined by the equation  $D = 2.2 \cdot 10^{-3} \exp(-16200/RT)$  cm<sup>2</sup>/sec. The data given in the papers by Fuller, Severiens, et al (Refs 1, 2) are in good agreement with results obtained in the present investigation. The data obtained by the present investigation indicate that the diffusion rate of lithium is independent of the structural perfection of the silicon crystals. This confirms that lithium diffuses through the interspaces between the nodes only. Furthermore, this data indicates the validity of the mechanism of the dependence of the diffusion rate on the structural perfection of the crystals, according to which diffusion proceeds at the lattice nodes and also in between. There are 2 figures, 1 table, and 6 references, 1 of which is Soviet.

ASSOCIATION: Institut metallurgii im. A. A. Baykova Akademii nauk SSSR  
(Institute of Metallurgy imeni A. A. Baykov of the Academy of Sciences, USSR)

Card 3/4

Diffusion of Lithium Into Silicon

66168

NOV/20-128-5-20/67

PRESENTED: May 27, 1959, by I. P. Bardin, Academician

SUBMITTED: April 30, 1959

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Card 4/4

PHASE I BOOK EXPLOITATION

SOV/3541

Shashkov, Yuriy Mikhaylovich

Metallurgiya poluprovodnikov (Metallurgy of Semiconductors) Moscow, Metallurgizdat, 1960. 212 p. Errata slip inserted. 5,200 copies printed.

Reviewers: B. A. Krasnyuk, Doctor of Technical Sciences, Professor, and A. A. Rudnitskiy, Doctor of Chemical Sciences; Ed. of Publishing House: O. M. Kamayeva; Tech. Ed.: P. G. Islent'yeva.

PURPOSE: This book is intended for technical personnel engaged in the development and production of semiconductors and semiconductor devices.

COVERAGE: The book deals with current problems in the metallurgy of semiconductors (germanium and silicon). Attention is given to physical, chemical, electrical, and optical properties of germanium and silicon, chemical and metallurgical purification, growth of single crystals, heat treatment, alloying, obtaining of electrically heterogeneous structures, and etching. The author thanks the following persons for their assistance in preparing the manuscript: N. V. Ageyev,

Card 1/7

Metallurgy of Semiconductors

SOV/3541

Corresponding Member, Academy of Sciences USSR; N. Kh. Abrikosov, Doctor of Chemical Sciences; D. A. Petrov, Doctor of Technical Sciences; B. A. Krasnyuk, Doctor of Technical Sciences; and A. A. Rudnitskiy, Doctor of Chemical Sciences. There are 293 references: 61 Soviet, 203 English, 19 German, 4 Japanese, 3 French, 2 Czech, and 1 Polish.

TABLE OF CONTENTS:

Preface	3
Ch. I. Physicochemical, Electrical, and Optical Properties of Germanium and Silicon	5
Physicochemical properties of germanium and silicon	5
Electrical properties of germanium and silicon	7
Optical properties of germanium and silicon	15
Ch. II. Chemical Methods of Purifying Germanium and Silicon	16
Production and purification of metallic germanium	17
Production and purification of metallic silicon	25
Acid rinsing of silicon	26
Production of silicon by zinc reduction of silicon tetrachloride (Beketov's method)	26
Iodide method of obtaining silicon	31

Card 2/7

Metallurgy of Semiconductors

SOV, 3541

Silane method of obtaining silicon	35
Trichlorosilane method of obtaining silicon	38
Production of silicon by hydrogen reduction of silicon tetra- chloride	40
Other methods of obtaining high-purity silicon	41
Ch. III. Metallurgical Methods of Purifying Germanium and Silicon	43
Principle of purifying by localized melting, gradual withdrawal of single crystals from melts, and oriented crystallization	43
Theory of distribution of impurities in gradual withdrawal of single crystals from melts, in oriented crystallization, and in localized melting	45
Distribution of impurities in gradual crystal withdrawal and in oriented crystallization	45
Distribution of impurities in localized melting	56
Volatilization of impurities during melting and crystal withdrawal in vacuum	67

Card 3/ 7

Metallurgy of Semiconductors

SOV/3541

Coefficient of distribution	70
Equipment used for purifying germanium and silicon by metallurgical methods	73
Process of purifying germanium and silicon by metallurgical methods	84
Purifying of germanium	84
Purifying of silicon	85
Utilization of reaction between gaseous and liquid phases	86
Purifying by extraction	87
Ch. IV. Growing Monocrystals of Germanium and Silicon	89
Methods of growing single crystals of germanium and silicon	90
Growing of single crystals by gradual withdrawal from melts	90
Method of horizontal localized melting	98
Method of vertical non-crucible localized melting	102
Other methods of growing single crystals of germanium and silicon	107
Crystallographic orientation and the shape of growing monocrystals	107
Macro- and microdefects in monocrystals of germanium and silicon	110
Macrodefects	111
Microdefects	118

Card 4/7



Metallurgy of Semiconductors

SOV/3541

Effect of growth conditions	125
Characteristic features of installations for growth of single crystals	126
Ch. V. Heat Treatment of Germanium and Silicon	129
Heat treatment of germanium	129
Heat treatment of silicon	133
Ch. VI. Diffusion of Impurities in Germanium and Silicon	139
Methods of measuring the diffusion coefficients of impurities in germanium and silicon	139
Diffusion of impurities in solid germanium and silicon	145
Ch. VII. Alloying of Germanium and Silicon	150
Alloying by introducing addition alloys into the melt	152
Crystal-withdrawal method	152
Localized-melting method	158
Preparation of the addition alloy	160
Alloying with elements in the gaseous phase	162

Card 5/7

Metallurgy of Semiconductors

SOV/3541

Distribution of impurities in a growing crystal	162
Alloying with elements in the gaseous phase	166
Alloying by diffusion of addition elements. Some other methods of alloying	163
Ch. VIII. Production of a Heterogeneous Electrical Structure in Mono-Crystals of Germanium and Silicon and Preparation of Ohmic Contacts	169
Production of electrically heterogeneous structures during the growth of monocrystals	169
Production of electrically heterogeneous structures during localized melting as a result of the temperature gradient	177
Production of electrically heterogeneous structures during partial melting of monocrystals	180
Production of electrically heterogeneous structures by fusing on other metals or alloys	182
Production of electrically heterogeneous structures resulting from diffusion of addition elements in the solid phase	187

Card 6/7

Metallurgy of Semiconductors

SOV/3541

Preparation of contacts	191
Ch. IX. Etching of Germanium and Silicon	193
Manifestation of macro- and microdefects and orientation of monocrystals	193
Etching of germanium	193
Etching of silicon	196
Etching of semiconductor devices	199
Bibliography	203

AVAILABLE: Library of Congress

Card 7/7

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S/180/60/000/004/025/027  
E193/E483

54210

AUTHORS: Abrikosov, N.Kh., Lyan-Tszun'-U, Shashkov, Yu.M.  
(Moscow)

TITLE: On the Volatility of Boric Oxide in Helium and Hydrogen in the Presence of Water Vapour

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1960, No.4, pp.156-159

TEXT: The rate of evaporation of boric oxide in dry and wet helium and hydrogen, at temperatures between 800 and 1400°C, was studied by the dynamic method. The results are reproduced in Fig.2 to 6. Fig.2 shows the temperature dependence of the vapour pressure  $p$  of  $B_2O_3$ . Fig.3 (plotted in the logarithmic scale) shows the decrease in weight of  $B_2O_3$ , per unit area ( $\Delta$ , mg/cm<sup>2</sup>) as a function of rate of flow of helium ( $V$ , l/h) of dry (broken curves) and wet (continuous curves) at various temperatures, the partial water vapour pressure in wet helium being  $P_{H_2O} = 0.0313$  atmospheres. Fig.4 illustrates the same relationship for dry (curve 1) and wet (curves 2 to 5) hydrogen. In Fig.5 the degree of saturation of wet helium with  $HBO_2$  vapour is plotted against the rate of flow of the helium-water mixture at various temperatures. Card 1/2

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On the Volatility of Boric Oxide in Helium and Hydrogen in the Presence of Water Vapour

Finally the temperature dependence of the vapour pressure of  $\text{HBO}_2$  at  $P_{\text{H}_2\text{O}} = 0.0313$  atm is shown in Fig.6. The latter relationship in the 1133 to 1637°K temperature range is described by

$$\log P_{\text{HBO}_2} = 5.043 - \frac{43.490}{4.575T}.$$

The conclusion reached was that the rate of evaporation of  $\text{B}_2\text{O}_3$  in helium and hydrogen increases considerably in the presence of water vapour. There are 6 figures and 15 references; 1 Soviet, 11 English, 1 French and 2 German.

SUBMITTED: March 22, 1960

Card 2/2

24.7700 (1043, 1138, 1143)  
26.2532

S/509/60/C00/004/021/024  
E193/E183

AUTHORS: Shashkov Yu. M., and Kolesnikova, T.P.

TITLE: Electrical Conductivity Isotherms of Binary  
Semiconductor Systems

PERIODICAL: Akademiya nauk SSSR. Institut metallurgii.  
Trudy, No.4, 1960. Metallurgiya, metallovedeniye,  
fiziko-khimicheskiye metody issledovaniya, pp.236-239

TEXT: Rapid progress in the fabrication of semiconductor devices brought about an increased demand for new semiconductor materials including inter-metallic compounds, alloys, sulphides, and oxides. Successful application of these materials depends on understanding of the effect of their composition on their properties, electrical properties in particular. The aim of the present authors was to analyse published experimental data and on this basis to formulate certain laws governing the variation of electrical conductivity in binary semiconductor systems, with particular reference to systems formed by oxides. Regarding the systems in which the second component is present in very small quantities it has been shown by various workers (Refs.1-5) that

Card 1/ 7

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E193/E183

# Electrical Conductivity Isotherms of Binary Semiconductor Systems

addition of a component which, on dissolution forms current carriers identical with those present in the solvent material. brings about an increase in conductivity whereas a decrease of conductivity is caused by addition of components of sign opposite to that of the intrinsic carriers of the solvent. In cases where both excess electrons and holes are present in equal quantities, electrical conductivity of the solvent is increased by the addition of any component capable of increasing the carrier concentration of either sign. This appears to be a general law, as is illustrated by data given in Fig 1, where the logarithm of electrical conductivity ( $\chi$ ,  $\text{ohm}^{-1}\text{cm}^{-1}$ ) of NiO (hole conductivity), ZnO (electron conductivity) and CuO (intrinsic conductivity) is plotted against  $\text{Li}_2\text{O}$  and  $\text{Cr}_2\text{O}_3$  content (mol -%). Regarding the systems formed by compounds with identical valency cations which usually form a series of solid solutions, analysis of the electrical conductivity isotherms of systems of the  $\text{Al}_2\text{O}_3$ - $\text{Cr}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ - $\text{Cr}_2\text{O}_3$ ,  $\text{MgO}$ - $\text{CoO}$   $\text{NiO}$ - $\text{MgO}$  systems shows that electrical conductivity of systems of this type changes monotonically from

Card 2/ 7

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E193/E183

# Electrical Conductivity Isotherms of Binary Semiconductor Systems

one component to another, except for very narrow composition ranges near each end of the system where sometimes minima may be present on the conductivity isotherm. The same applies to heterogeneous systems such as  $\text{CaO-ZrO}_2$ ,  $\text{Al}_2\text{O}_3\text{-SiO}_2$ ,  $\text{TiO}_2\text{-SiO}_2$ , except that the isotherm will pass through a sharp maximum at compositions corresponding to compounds formed by the two components. This case is illustrated in Fig.2, where the resistivity ( $\rho$ , ohm.cm) at 1000 °C is plotted against the composition of the  $\text{ZnO}_2\text{-CaO}$  system. When the electrical conductivity isotherms are compared with the constitution diagrams of the corresponding systems, the former curves frequently show minima and maxima whose presence cannot be explained in terms of changes in the constitution of the system studied. The  $\text{CaO-Cr}_2\text{O}_3$ ,  $\text{MgO-NiO}$ ,  $\text{Al}_2\text{O}_3\text{-Cr}_2\text{O}_3$  systems provide typical examples of this effect. The presence of these extrema may sometimes be incidental, being caused for instance by predominance of the surface conductivity at certain compositions (the  $\text{Al}_2\text{O}_3\text{-Cr}_2\text{O}_3$  system) or by the effect of one component being compensated by the impurity present in the other component. In some cases,

Card 3/7



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# Electrical Conductivity Isotherms of Binary Semiconductor Systems

however, the minima and maxima of electrical conductivity constitute an intrinsic property of the system which is associated with the nature of conductivity of semiconductors. CaO-Li<sub>2</sub>O (Fig.3) and CaO-Y<sub>2</sub>O<sub>3</sub> (Fig.4) systems represent two such cases. The curves on Figs. 3 and 4 represent conductivity ( $\chi$ , ohm<sup>-1</sup>cm<sup>-1</sup>) curves constructed for the CaO-rich ends of the systems from measurements carried out at 100 and 10<sup>-4</sup> mm Hg at which CaO (amphoteric semiconductor) has electron and hole conductivity, respectively. In general, increasing the Li<sub>2</sub>O and Y<sub>2</sub>O<sub>3</sub> content causes variation of the electrical conductivity of CaO in accordance with the law discussed at the beginning of the present paper, i.e. the conductivity is either increased or decreased, depending on the sign of the carriers in CaO and in the other component. However, in both systems, the isotherms showing the variation of conductivity for the case when this property is decreased by the addition of the other component, have minima. Analysis of changes taking place in this case shows that when electrical conductivity is reduced the number of current carriers

Card 4/7

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S/509/60/020/004/021/024  
E193/E183

Electrical Conductivity Isotherms of Binary Semiconductor Systems  
of one type decreases up to a certain limit, characterized by the minimum of conductivity, after which the sign of the carriers changes (i.e. electron conductivity changes into hole conductivity and vice versa) and their number increases. This means that in this case, the presence of minima on conductivity isotherms is not associated with the formation of a new phase but is caused by changes of the mechanism of conduction due to dissolution of the solid component. In the final paragraph, the difference between the shape of electrical conductivity isotherms of binary semiconductor and metal systems is discussed. In contrast to metals, addition of a second component to a semiconductor in systems in which substitutional solid solutions are formed may not only decrease the electrical conductivity but also increase it, and the conductivity isotherm for a binary semiconductor system, forming a series of solid solutions, has no minimum. In addition, when a compound is formed in a binary semiconductor system, the electrical conductivity does not increase, but decreases. There are 4 figures and 15 references: 6 Soviet and 9 non-Soviet.  
Card 5/7

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Electrical Conductivity Isotherms... P193/E185

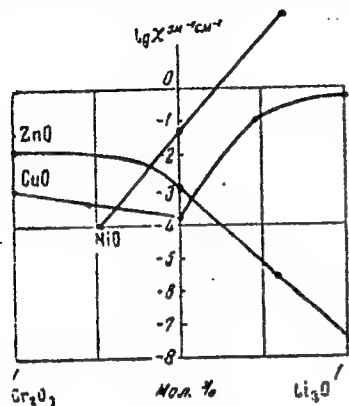


Рис. 1

Fig. 1

Card 6/7

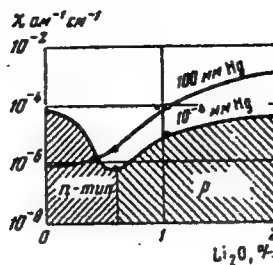


Рис. 3

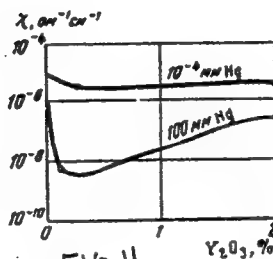


Fig. 4

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Electrical Conductivity Isotherms ... E193/E183

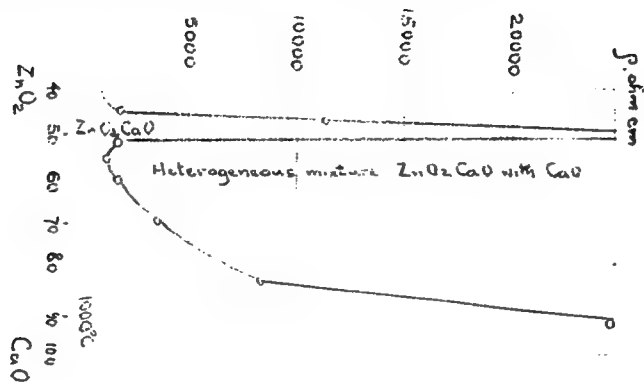


Fig.2

Card 7/7

ABRIKOSOV, N.Kh. (Moskva), LIAN TSZUN'-U [Liang Tsun-wu]; SHASHKOV, Yu.M.  
(Moskva)

Oxygen solubility in molten silicon. Izv. AN SSSR. Otd. tekhn. nauk.  
Met. i topl. no.6:65-68 N-D '60. (MIRA 13:12)

(Silicon—Oxygen content)  
(Liquid metals—Oxygen content)

S/137/62/000/005/006/150  
A006/A101

AUTHOR: Shashkov, Yu. M.

TITLE: Electric conductivity of titanium containing slags

PERIODICAL: Referativnyy zhurnal, Metallurgiya, no. 5, 1962, 10-11, abstract  
5A66 (V sb. "Fiz-khim. osnovy proiz-va stali", Moscow, AN SSSR,  
1961, 262-265)

TEXT: The author studied electric conductivity of slags in system  $TiO_2 - SiO_2 - Al_2O_3 - CaO - MgO$ . The experiments were carried out under reduction conditions. The slag resistance between the central Mo-electrode and the graphite crucible, arranged co-axially, was measured. In the slags investigated, the  $Ti_2O_3/TiO_2$  ratio was 0.1 - 0.3 and did practically not change during the measurements. The results obtained show a considerable influence of the slag composition on its conductivity. It is assumed that the structure, revealed in titanium slags in solid state, is also reserved in liquid condition. This predetermines the semiconductor nature of the melt conductivity. Changes in the electric conductivity at a varying ratio and quantity of slag components are

Card 1/2

Electric conductivity of titanium containing slag

S/137/62/000/005/006/150  
A006/A101

explained by changes in the portion and type of oxides, dissociated into ions.

Yu. Nikitin

[Abstracter's note: Complete translation]

Card 2/2

S/137/62/000/006/006/163  
A006/A101

AUTHOR: Shasnikov, Yu. M.

TITLE: Some problems of zonal melting of metals

PERIODICAL: Referativnyy zhurnal, Metallurgiya, no. 6, 1961, 15, abstract 6A84  
(In collection: "Fiz.-khim. osnovy proiz-va stali", Moscow, AN SSSR, 1961, 315 - 319)

TEXT: The author attempted to estimate theoretically the effect of the interaction of metal refined by zonal melting in a crucible and the crucible material, upon the distribution of admixtures over the ingot length after passage through the zone. Some factors are pointed out which should be taken into account when developing a unit for the zonal melting of metal.

T. Kolesnikova

[Abstracter's note: Complete translation]

Card 1/1



SHASHKOV, Yu.M., LIAN TSIN-U [Liang Ch'ing-wu]

Kinetics of the heterogenous reaction between silicon melts and a mixture of hydrogen vapor and helium vapor. Izv. vys. ucheb. zav.; Chern. met. 6 no.7:27-32 '63. (MIRA 16:9)

1. Gosudarstvennyy nauchno-issledovatel'skiy proyektnyy institut redkometallicheskoj promyshlennosti, Moskva.  
(Vapor-liquid equilibrium) (Silicon alloys--Testing)

L 12871-63 EWP(q)/EWT(m)/BDS AFFTC/ASD/APGC WH/JD  
 ACCESSION NR: AP3002941 S/0076/63/037/006/1397/1399 60

AUTHOR: Shashkov, Yu. M.; Kolesnikova, T. P.

TITLE: Surface tension<sup>27</sup> of semiconductor silicon<sup>27</sup>

SOURCE: Zhurnal fizicheskoy khimii, v. 37, no. 6, 1963, 1397-1399

TOPIC TAGS: surface tension, oxygen, boron, phosphorus, quartz, silicon, semiconductor

ABSTRACT: <sup>27</sup>The effect on the surface tension of silicon of semiconducting purity of oxygen, boron (acceptor), phosphorus (donor), and quartz<sup>27</sup> was evaluated by the method of weighing drops of molten silicon falling from the end of a cylindrical bar. O (10 sup 16 to 10 sub 18 atoms/cu cm) had little effect on the surface tension; B (to 10 sup 20 atoms/cu cm) also had little effect; while P had a tendency to lower the surface tension and quartz increased it slightly. (O, B, P are quartz impurities in Si.). "In conclusion the authors consider it their duty to express appreciation to Liang Tsum for help in the experimental work." Orig. art. has: 1 table and 1 equation.

ASSOCIATION: None

Card 1/2/

ACCESSION NR: AT4035157

S/2765/64/000/000/0372/0375

AUTHOR: Shashkov, Yu. M.

TITLE: Dynamic alloying from the gas phase

SOURCE: Konferentsiya po fiziko-khimicheskim osnovam proizvodstva stali. 6th, 1961. Fiziko-khimicheskiye osnovy\* proizvodstva stali (Physicochemical basis of steel production); trudy\* konferentsii. Moscow, Izd-vo "Nauka," 1964, 372-375

TOPIC TAGS: steel, alloying, dynamic alloying, gas phase alloying, silicon anti-mony fusion, silicon phosphorus fusion, semiconductor alloying, admixture distribution

ABSTRACT: The author describes the principles and techniques of dynamic alloying and gives the mathematical treatment for a quantitative calculation of the concentration and distribution of admixtures in the ingot during alloying from a gas phase in the process of zonal fusion. In a typical process, the vaporized alloying element is conveyed in a high-vacuum assembly from a vaporizer through a heated tube to the fused zone. From the amount of admixture fed into the fusion zone,

$\beta p \Phi dt,$

(1)

Card 1/2

ACCESSION NR: AT4035157

where  $\beta$  is the coefficient of accommodation,  $\Phi$  is the coefficient of losses due to geometrical factors,  $\phi$  is the addition input from the vaporizer tube and  $t$  is time, the author derives a series of equations for the factors acting on the concentration of the admixture in the zone (vaporization, melting, crystallization) and arrives at final equations which allow technical estimates of the required amounts of alloying element and control of its addition. The representative process of silicon-antimony and silicon-phosphorus fusing is discussed and the apparatus used is described. Orig. art. has: 4 figures and 15 formulas.

ASSOCIATION: none

SUBMITTED: 00

DATE ACQ: 30Apr64

ENCL: 00

SUB CODE: MM

NO REF SOV: 001

OTHER: 004

Card 2/2

ACCESSION NR: AT4040557

S/2564/64/004/000/0117/0121

AUTHOR: Shashkov, Yu. M.; Rozhdestvenskaya, V. V.

TITLE: Growth of silicon carbide crystals from the gaseous phase

SOURCE: AN SSSR. Institut kristallografi. Rost kristallov, v. 4, 1964, 117-121

TOPIC TAGS: silicon carbide, single crystal growth, silicon carbide crystal, crystal growth equipment, vapor phase growth, silicon carbide sublimation

ABSTRACT: Growth of silicon carbide single crystals by deposition from the vapor phase on a silicon carbide substrate has been analyzed from the standpoint of vapor supersaturation, a factor not considered in earlier studies. The  $\alpha$ -type crystals were grown in an argon atmosphere in a specially built vacuum furnace under a temperature gradient excluding the effect of heat radiation on the growth process. Details of the furnace, a graphite crucible, and an inner perforated graphite cylinder containing the powdered substrate are presented

Card 1/2

ACCESSION NR: AT4040557

schematically. It was shown experimentally that the effect of vapor supersaturation is determined by the diameter of perforations and the temperature (height) of the substrate. The linear dimensions of a crystal reach a maximum at certain values of the diameter of perforations and the height of the substrate. In the early stage of crystallization, the crystal volume increases proportionally to the cube of the time of growth; then, it increases proportionally to the time. The slowing of the growth rate is interpreted in terms of the leveling of the supersaturation; the smaller the perforations, the earlier the leveling occurs, i.e. there is no longer a direct dependence of the growth rate on supersaturation. Thus, besides supersaturation in the vapor phase near the substrate, the most important factors in the growth process are the dimensions of the crucible and the charge. Orig. art. has: 6 figures.

ASSOCIATION: none

SUBMITTED: 00

DATE ACQ: 02Jul64

ENCL: 00

SUB CODE: SS

NO REF SOV: 000

OTHER: 004

Card 2/2

81

ACCESSION NR. AP4034927

S/0181/64/006/005/1449/1452

AUTHOR: Shashkov, Yu. M.; Shushlebina, N. Ya.

TITLE: Growing silicon carbide from a silicon melt

SOURCE: Fizika tverdogo tela, v. 6, no. 5, 1964, 1449-1452

TOPIC TAGS: silicon carbide, silicon carbide growing, silicon, silicon melt, single crystal, single crystal growing

ABSTRACT: The growing of  $\beta$ -SiC single crystals from a Si melt has been studied at the State Scientific Research and Design Institute of the Rare-Metals Industry, Moscow. This work was done because the growing of SiC from metal melts may lower considerably the temperature of the growing and facilitate the doping of SiC single crystals. Single-crystal Si with an electrical resistivity of 10-20 ohm-cm was melted in a graphite crucible in vacuum ( $10^{-4}$  mm Hg) in a resistance furnace similar to furnaces used for pulling Si single crystals. The furnace was equipped with a Ta heating element and a device which made it possible to lower and rotate the crucible

Card 1/3

ACCESSION NR. AP4034927

and raise and lower the seed. The temperature was controlled by a thermocouple placed at the bottom of the crucible. The moment of melting was observed visually. To measure the temperature gradient in the melt, an additional thermocouple was lowered into the melt. The experiment was carried out as follows: the Si sample (about 3 g) was placed in the crucible. The furnace was evacuated, and the heat was turned on. After the Si had melted, the melt was superheated to a predetermined temperature and held at that temperature for a definite amount of time. During that time the Si evaporated markedly. Then the furnace heat was turned off, and the melt crystallized rapidly. Rapid cooling was selected after special experiments which showed that crystal growth proceeds almost exclusively by the transfer of the SiC formed from the hot zone to the cold. After removal of the crucible from the furnace, the Si was leached out with a mixture of HF and HNO<sub>3</sub>. The SiC crystals obtained were transparent single crystals yellowish in color, and cubic, columnar prismatic, octohedric, and lamellar in shape. The crystals could be divided into three fractions according to size. The largest

Card 2/3



ACCESSION NR. AP4034927

crystals were 0.1-0.5 mm thick and 1.5-2 mm long. The large-size fraction consisted mainly of columnar crystals elongated along the prism axis. Goniometric measurements showed that the principal plane forming the crystals is the (111) plane. The replacement of the vacuum with argon, which lowers Si evaporation to practically zero, had no noticeable effect on the shape of the growing crystals. Hence it is concluded that the main role in the determination of the character of crystallization is played by the temperature factor. Orig. art. has: 3 figures and 1 table.

ASSOCIATION: Gosudarstvennyy nauchno-issledovatel'skiy i proyektnyy institut redkometallicheskey promyshlennosti, Moscow (State Scientific Research and Design Institute of the Rare-Metals Industry)

SUBMITTED: 29Nov63

DATE ACQ: 20May64

ENCL: 00

SUB CODE: CH,PH

NO REF SOV: 000

OTHER: 002

Card 3/3

L 21109-65 LPF(c)/EPR/ENG(j)/ENT(m)/EWP(b)/T/EWP(e)/EWP(t) Pr-4/PS-4  
 AFWL/ASD(a)-5/AS(mp)-2/RAEM(c)/ESD(gs)/ESD(t) WH/WW/JD  
 ACCESSION NR: AP5002164 S/0120/64/000/006/0150/0151

AUTHOR: Abayev, B. I.; Bezobrazov, N. T.; Shashkov, Yu. M.

TITLE: Slit <sup>15</sup>graphite heater for single-crystal-growing devices <sup>16</sup>B

SOURCE: Priory i tekhnika eksperimenta, <sup>9</sup>no. 6, 1964, 150-151

TOPIC TAGS: single crystal, single crystal growing, single crystal growing device

ABSTRACT: The State Scientific Research and Planning Institute of the Rare Metals Industry has designed and built a furnace for growing single crystals of semiconductor materials. The furnace has a special graphite heater with vertical slits which permit the direct heating of material by an RF field (see Fig. 1 of the Enclosure). The graphite block acts as a transformer creating inside the crucible a high-frequency field which ensures an intensive stirring of the molten material. The graphite block also acts as a radiation heater. The new device requires 30% less power and makes it possible to increase the pulling speed, which attains 10 mm/min in pulling silicon single crystals 10 mm in diameter. Orig. art. has: 2 figures.

Card 1/3

L 21109-65

ACCESSION NR: AP5002164

ASSOCIATION: Giredmat

SUBMITTED: 06Dec63

ENCL: 01

SUB CODE: SS, MM

NO REF SOV: 000

OTHER: 000

ATD PRESS: 3164

Card 2/3

L 21109-65

ACCESSION NR: AP5002164

ENCLOSURE: 01

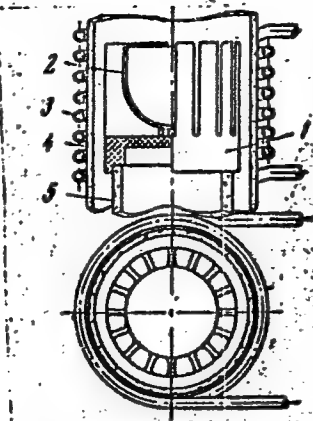


Fig. 1. Furnace layout

1 - Graphite heater; 2 - quartz crucible; 3 - inductor; 4 - quartz shield; 5 - quartz base.

Card 3/3

L 24709-65 EWT(m)/I/EWP(t)/EWP(b) AFWL/ASD(a)-5/AS(mp)-2/RAEM(c)/ESD(gs)/ESD(t)  
IJP(c) JD

ACCESSION NR: AP5002582

S/0076/64/038/012/2992/2995

AUTHOR: Shashkov, Yu. M.; Grishin, V. P.

TITLE: Rate of silicon growth from melt

SOURCE: Zhurnal fizicheskoy khimii, v. 38, no. 12, 1964, 2992-2995

TOPIC TAGS: silicon single crystal, single crystal growth, silicon dendrite, melt grown crystal, maximum growth rate, rate molecular constant

ABSTRACT: The maximum rate of growth of silicon dendrites from a supercooled melt was measured at supercoolings of 4—15K in order to determine the molecular constant (k) of the growth rate of silicon single crystals. The experimental determination of k was desirable because of the wide discrepancy in theoretical values and the importance of k in estimating various factors in the growth of single crystals. Silicon was vacuum melted and, after seeding, the dendrite was pulled out at an increasing pulling rate until it dwindled to the shape of a needle. The pulling rate, corresponding to the moment at which the needle breaks away, was taken as a maximum growth rate

Card 1/2

L 24709-65

ACCESSION NR: AP5002582

( $V_m$ ) of the needle at a given supercooling. The needles consisted of twins. Calculation of  $k$  was carried out, using the formulas derived by D. Ye. Temkin (Dokl. AN SSSR, 132, 1307, 1960) and the experimental  $V_m$  values. The curvature radius of the top end of the needle was also calculated from the Temkin formulas. Calculations based on the  $k$  value for silicon, which was found to be 0.64 cm/sec-deg, and on the Temkin formula gave the  $V_m$  values which were in agreement with the experimental  $V_m$  data over the entire range of supercoolings. The sources of error in the determination of  $k$  were discussed. The  $k$  values obtained were compared with those for germanium. The need was stressed for further study of the growth process of dendrites and for application of the Czochralski method to produce a more accurate  $k$  value. Orig. art. has: 2 figures and 4 formulas.

ASSOCIATION: GIREDMET

SUBMITTED: 01Oct63

ENCL: 00

SUB CODE: MM, SS

NO REF SOV: 004

OTHER: 012

ATD PRESS: 3167

Card 2/2

MORCZOV, V.I.; VORONILIN, N.Y.; NADIN, Y.V.; GAGMAZA, V.A.; MEDVEDEV, G.I.;  
KAMENETSKIY, I.M.; LUKIN, V.V.; BARASHKOV, V.D.; EMPARAPULO, V.Kh.;  
RAJEVSKIY, N.S.; SHASHKOV, Yu.M.; GRISHIN, V.P.; SMYSLOV, I.I.;  
ROMANENKO, Yu.M.; SAKHAROV, B.B.

Innovations. Avia. 1 (rib. no.2:61-62 Ap-Je '65.

(MIRA 18:7)

SHASHKOV, Yu.M.; SHUSHLEBINA, N.Ya.

Formation of nondislocated silicon single crystals at the increased rates of pulling. Izv. AN SSSR. Neorg. mat. 1 no.5:643-647 My '65.  
(MIRA 18:10)

1. Gosudarstvennyy nauchno-issledovatel'skiy i proyektnyy institut redkometallicheskoj promyshlennosti, Moskva.



L 63625-65 EEC(b)-2/EWA(c)/EWT(1)/EWT(m)/ENP(b)/T/ENP(t) Pi-h TJP(c) GG/JD  
 UR/0020/65/162/006/1349/1351  
 ACCESSION NR: AP5017211

AUTHOR: Shashkov, Yu. M.; Grishin, V. P.

TITLE: Structure of silicon dendrites

SOURCE: AN SSSR. Doklady, v. 162, no. 6, 1965, 1349-1351, and insert facing p. 1341

TOPIC TAGS: silicon dendrite, crystal growth, dendrite structure, germanium dendrite

ABSTRACT: Dendrites grown from a supercooled silicon melt were studied. Etching was done with  $H_2CrO_4$  + HF (1:1). The cross section was studied by breaking the dendrites and also by etching. After a series of experiments, an etchant of the composition HF +  $HNO_3$  (1:2) was chosen. As in the case of germanium dendrites, the broad planes of silicon dendrites are the (111) planes, and the growth of dendrites proceeds in the (112) direction. The broad planes usually have three bands of dislocations along the dendrite: a central band (dislocation density  $10^5$ - $10^6$   $cm^{-2}$ ) and two more diffuse lateral bands ( $10^3$   $cm^{-2}$ ). The distribution of dislocations is described. An examination of the cross section

Card 1/2

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ACCESSION NR: AP5017211

showed that in most of the dendrites, twinning planes pass through the entire dendrite, and that there are usually two twinning planes separated by a distance of 7-10 $\mu$ . The impurity distribution in the cross section has an H-shaped character, as in germanium dendrites. The transition region between the needle and the dendrite, as well as the needle itself are described in terms of thickness, dislocation bands, and twinning planes. The study shows that the structure of silicon dendrites and their segregation characteristics are similar to those of germanium dendrites. From a comparison of the structure of the needles and dendrites and of the transition region, it is concluded that the growth of silicon dendrites, like that of germanium dendrites, occurs in two stages. Orig. art. has: 3 figures. 27

ASSOCIATION: Gosudarstvennyy nauchno-issledovatel'skiy i proyektnyy institut redkometallicheskoj promyshlennosti (State Scientific Research and Planning Institute of the Rare Metal Industry).

SUBMITTED: 31Dec64

ENCL: 00

SUB CODE: IC, SS

NO REF SOV: 004

OTHER: 002

Card <sup>KC</sup> 2/2

L 64456-65 EWT(1)/ENT(m)/T/ENP(t)/ENP(b)/EWA(c) IJP(c) JD/GG

ACCESSION NR: AP5020835

UR/0020/65/163/004/0942/0944

AUTHOR: <sup>44, 65</sup>Shashkov, Yu. M.; <sup>44, 65</sup>Grishin, V. P. <sup>37</sup>  
<sup>21, 44, 65</sup>

TITLE: Supercooling at the crystallization front during the growth of silicon mono-  
crystals by the Czochralski method <sup>27</sup>

SOURCE: AN SSSR. Doklady, v. 163, no. 4, 1965, 942-944

TOPIC TAGS: silicon single crystal, germanium single crystal, single crystal  
growth, supercooling, crystallization <sup>27</sup>

ABSTRACT: Supercooling at the crystallization front during the growth of Si 111  
monocrystals was determined by two methods. Temperature changes during  
crystal growth were measured in the melt (I) at the meniscus (II) and in the crys-  
tal (III). The temperature gradient was least in I and greatest in III, but was  
constant within each segment of the curve. Supercooling, determined directly at  
the point of intersection of II and III was 2.4 C for a crystal growth rate of  
2 mm/min. Temperatures at the melt-meniscus interface were measured during  
the crystal drawing and when the drawing was stopped. Supercooling was then  
Card 1/3

L 64456-65

ACCESSION NR: AP5020835

determined from the equation

$$S\lambda \frac{T_{u_2} - T_0}{h_2} = \lambda S \frac{T_{u_1} - T_0 + \Delta T}{h_1} + sLv d,$$

where S is crystal cross section;  $\lambda$  -- heat conductivity of the melt;  $T_0$  -- Si crystallization temperature;  $T_{u_1}$  and  $T_{u_2}$  -- temperatures under meniscus during crystal drawing and when drawing was shut down;  $h_1$  and  $h_2$  -- height of interface rise during crystal drawing and during shut-down;  $\Delta T$  -- supercooling at the interface;  $v$  -- rate of drawing;  $L$  -- heat of crystallization and  $d$  -- density of the melt. Supercooling was  $2.35 \pm 0.21^\circ\text{C}$  when  $v = 2\text{ mm/min}$ . Supercooling at the crystal-melt interface increased sharply as  $v$  increased from 1-3 mm/min, and increased much less when  $v > 4\text{ mm/min}$ , while keeping the crystal diameter constant. There was no noticeable change in the supercooling when the crystal diameter was increased from 10-26 mm while maintaining  $v$  constant. It was concluded the crystallization mechanisms in Ge and Si are similar in view of the agreement of supercooling values between these crystals. Orig. art. has: 2 figures and 1 equation

C678 2/3

L 64456-65

ACCESSION NR: AP5020835

ASSOCIATION: None

SUBMITTED: 13Jan65

ENCL 00

SUB CODE: SS

NR REF SOV: 003

OTHER: 006

*llc*  
Card 3/3

L 10922-66 EWT(1)/ENT(m)/EPF(n)-2/T/EMP(t)/EMP(b)/EWA(c) LJP(c) JL/WJ/JG/GG  
 ACC NR: AP5027181 SOURCE CODE: UR/0076/65/039/010/2559/2560

AUTHOR: <sup>44, 55</sup> Shashkov, Yu. M.; <sup>44, 55</sup> Mel'nikov, Ye. V.

ORG: <sup>44, 55</sup> Giredmet

TITLE: Effect of surface tension on the position of the crystallization front during growing of semiconductor single crystals by the Chokhral'skiy method

SOURCE: Zhurnal fizicheskoy khimii, v. 39, no. 10, 1965, 2559-2560

TOPIC TAGS: <sup>21.44.55</sup> single crystal growth, germanium single crystal, silicon single crystal, surface tension, crystallization, semiconductor single crystal

ABSTRACT: The position of the crystallization front over silicon and germanium melts was measured under various pulling conditions. The melts were heated by electron bombardment at  $10^{-5}$  —  $10^{-6}$  mm Hg, and the height of ascent  $h$  of the melt was photographed during growth of a crystal of constant diameter. Changes in thermal conditions associated with changes in pulling rate, ingot diameter, and rotation rate (i.e., with temperature gradients in the ingot and in the melt near the crystallization front) were found to have virtually no effect on the height of ascent of the melt. The height of ascent does vary in regular fashion with the diameter of the growing crystal, rising sharply at first, then tending toward a constant value; it is lower for germanium than for silicon. The data show that the surface tension has a major influence on the height of ascent of the crystallization front. High-speed motion-picture photography (up to 2000 frames/sec) showed that the angle between the surface

Card 1/2

UDC: 621.315.592

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ACC NR: AP5027181

of the growing crystal and the melt fluctuates both with time and with the crystallization front, and amounts to an average of 15 to 20° during growing of constant-diameter ingots. Orig. art. has: 3 figures.

SUB CODE: 20 / SUBM DATE: 29Feb64 / ORIG REF: 001 / OTH REF: 003

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Card 2/2

L 39732-86 EWT(1)/EWT(A)-2/EWA(1) WW/MS-1

ACC NR: AP6006849

SOURCE CODE: UR/0181/66/008/002/0567/0569

AUTHOR: Shashkov, Yu. M.; Grishin, V. P.

ORG: State Scientific Research Institute of the Metal and Rare Metal Industry,  
Moscow (Gosudarstvennyy nauchno-issledovatel'skiy institut redkoy i metallicheskey  
promyshlennosti)

TITLE: Thermal conductivity of silicon in the solid and liquid states close to the  
melting point

SOURCE: Fizika tverdogo tela, v. 8, no. 2, 1966, 567-569

TOPIC TAGS: heat conductivity, silicon, phase transition, heat balance, single  
crystal, crystal growth, temperature gradient, melting point

ABSTRACT: The authors studied the thermal conductivity of silicon close to the  
melting point by measuring the thermal balance at the crystallization front during  
crystal pulling by the Czochralski method. The equipment and procedure used in the  
experiment are briefly described. The curve for the change in temperature during  
growth of the crystal shows three sections which are close to linear. The first sec-

Card 1/2



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ACC NR: AP6006849

tion has the lowest temperature gradient and corresponds to the variation in temperature in the melt. The second section has an intermediate temperature gradient and corresponds to the meniscus due to surface tension. The section with the steepest temperature gradient corresponds to the crystal. There is a considerable difference between the temperature gradient of the melt and the meniscus which is in direct contact with the crystallization front. It is found that the temperature gradient in the meniscus is a linear function of the temperature gradient in the crystal. Metallographic analysis showed that the crystallization front in these experiments was close to linear. The thermal conductivities were found to be  $0.075 \pm 0.007$  cal/cm/sec/deg for the solid phase and  $0.16 \pm 0.02$  cal/cm/sec/deg for the liquid phase. Orig. art. has: 2 figures.

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AUTHOR: Shashkov, Yu. M.; Mel'nikov, Ye. V.

TITLE: Surface phenomena in pulling single crystals by the Czochralski method

SOURCE: Ref. zh. Fizika, Abs. 3A404

REF SOURCE: Sb. Poverkhnostn. yavleniya v rasplavakh i voznikayushchikh iz nikh tverd. fazakh. Nal'chik, 1965, 585-589

TOPIC TAGS: crystallography, crystal growth, semiconductor crystal, crystal pulling, Czochralski method, germanium crystal, silicon crystal

ABSTRACT: A study was made of the effects of the parameters of pulling germanium and silicon single crystals with a constant cross section on the rise of the melt up to the crystallization boundary. It was found that the height of pulling is practically independent of the rate of pulling and speed of rotation of the crystal being pulled. In excluding the pulling mechanism of the crystal by varying the temperature, one can change the rise which affects the diameter of the crystal. The curve showing the dependence of the rise on the crystal diameter lies

Card 1/2

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MC: 19541-.R3

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Reference Department, Washington, 1952, Unclassified.